International Journal of Electrical, Electronics and Computer Engineering **1**(1): 47-51(2012)

ISSN No. (Online) : 2277-2626

An Intelligent Diagnosis System for Electrocardiogram (ECG) Images Using Artificial Neural Network (ANN)

Jasminder Kaur* and J.P.S. Raina*

**Department of Electronics and Communication Engineering, BBSBEC Fatehgarh Sahib, (PB)*

(Recieved 15 April, 2012 Accepted 05 May, 2012)

ABSTRACT : Electrocardiogram (ECG) is a record of the origin and propagation of electrical potential through cardiac muscles. Electrical activity of the heart is called as electrocardiogram. ECG's provide lots of information about heart abnormalities. ECG trace is an image based on which disease detection is made. It represent signal of cardiac physiology, useful in diagnosing cardiac disorders, where ECG can provide a lot of information regarding the abnormality in the concerned patient [5].

ECGs are analysed by the physicians and the interpretation may vary depending upon their experience [5]. Hence this paper focuses on computer based automated system in the analysis of the ECG signals in which the images are fed into the system and the software extracts the ECG signal from the image and feed it to the ANN (Artificial Neural Network) classifier. ANN has its own database of diseased ECG recordings which will match the inputted ECG to the existing one so that they must be diagnosed and interpreted accurately irrespective of the physicians. Furthermore, it shall display the normality or abnormality of the signal so as to start the early treatment for the problems and many lives could be saved. Converting ECG records into a computer based digitised signal reduces the physical storage space and the retrieval of the requisite information can be made quicker and accurate [3]. The soft computing technique used for carrying out the automation is MATLAB 7.7.

Keywords: Artificial Neural Network, Correlation, Dilation, Image Binarization, Morphological Filtration, Radon Transform, Standard Deviation, Wavelet Coefficient.

I. INTRODUCTION

Cardiac diseases are one of the most common causes of death, killing millions of people worldwide each year. However, they can be effectively prevented by early diagnosis. ECG signal is the most important and powerful reference tool used contains the diagnosis and treatment of heart diseases. ECG represents the electrical activity of the heart and contains vital information about its rhythmic characteristics.

The medical state of the heart is determined by the shape of the Electrocardiogram, which contains important pointers to different types of diseases afflicting the heart. However, the electrocardiogram signals are irregular in nature and occur randomly at different time intervals during a day [2].

Today many patients are suffering from cardiac problems. Heart disease is the most common cause of death in the world. In recent years considerable work has been done to assist cardiologists with their task of diagnosing the ECG recordings. The biggest challenge faced today is the early detection and treatment of arrhythmias. All the samples taken have one thing in common and that is, they are analysed by the experienced doctors who depending upon their knowledge predict out the problem(s) associated with the patient which is disturbing the normal morphology of the signal. If this morphological disturbance becomes somewhat complex then it is analysed by them depending upon their experience. This experience based analysis gives different interpretations [4]. Conventionally, each ECG has to be printed on a thermal paper and stored in the hospital for further diagnosis. Hence there is a need of a system that could analyse the ECG signals properly and with a great accuracy so that there is a less chance of mistake as well as the problem is spotted in time so that an early treatment could be started [4].

The models for proposed for heart beat classification is challenged by the variability of the ECG waveforms from one patient to another even within the same person. However, different types of arrhythmias have certain characteristics which are common among all the patients. Thus, there arises the need for continuous monitoring of the ECG signals, which by nature are complex to comprehend and hence there is a possibility of the analyst missing vital information which can be crucial in determining the nature of the disease. Thus computer based automated analysis is recommended for early and accurate diagnosis. So to achieve this objective many works have been done in this field based on image processing, Digital Signal Processing etc and prominent among them is the use of Artificial Neural Networks which has given promising results to such complex problems [1].

This paper focuses on the method of Digital Time series signal generation of ECG wave and its classification using Neural Networks for Normality and Abnormality detection. The neural models are basically based on the perceived work of the human brain. The artificial model of the brain is known as Artificial Neural Network (ANNs) or simply Neural Networks (NNs). Generally, the ANNs are a cellular information processing system designed and developed on the basis of the perceived notion of the human brain and its neural system. Neural networks are one of the most efficient pattern recognition tools because of their high nonlinear structure and tendency to minimise error in test inputs by adapting itself to the input output pattern and thus establishing a nonlinear relationship between the input and output.

II. OBJECTIVE OF THE WORK

The objective of this work is to identify the normal beats from ECG beats so that other beats can be detected as abnormal beats by use of soft computing technique MATLAB based neural network and the patient could be diagnosed for the heart problems in less time as well more accurately so that the medical practitioners have primary information about the ailment and could start a treatment early.

III. METHODOLOGY AND ANALYSIS

The paper basically consists of two parts. The first is the digital time series signal generation of the input ECG signal and the other is the classification of the ECG using MATLAB based Neural Network Toolbox. The output signal generated from the first step *i.e.* digital time series Signal generation serves as an input or Real data to the second step i.e. the Classification of ECG using Neural Network for the normal or abnormal diagnoses of the ECG.

A. Digital Time Series Signal Generation

The Signal generation of the input ECG signal comprises of the calculation of certain parameters like Heart Rate, Peak values of input ECG Wave, Width of the ECG wave which undergoes various processes. For this purpose the recorded ECG signal of the patient on the thermal paper using conventional method is scanned and stored in jpeg format. The Image is loaded and the Radon Transformation is applied for detection and correction of skewness [3]. On the Deskewed image, Image Binarization and Morphological Dilation is performed which then undergoes Otsu's algorithm and the Peak detection is done to calculate Heart rate.

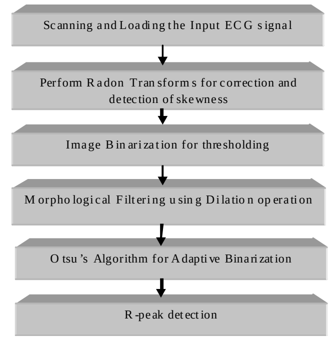

Fig. 1. Algorithm for digital Time series Signal generation.

(*a*) Scanning and Loading the Input ECG signal: The ECG data of the patients obtained through Thermal papers are scanned with the higher resolution and saved in jpeg format. The saved Scanned images are then loaded and serves as an input.

(*b*) Performing Radon Transforms: Scanning process may result in image skewness either due to faulty scanners or human error. To extract the faithful ECG signals the Skewness has to be elimininated for which axis is required. Hence Radon Transform is applied to find the angle of skewness. The radon function computes the line integrals from multiple sources along parallel paths, or beams, in a certain direction. The beams are spaced 1 pixel unit apart. To represent an image, the radon function takes multiple, parallel-beam projections of the image from different angles by rotating the source around the center of the image.

(*c*) Image Binarization and Morphological Filtering using Dilation operation: The extraction of ECG Signals from an image depends on its accurate separation from rest of the attributes present in the image like grid lines, textual characters, noise signals etc [3]. For this input image is binarized using image processing filters and image thresholding. Morphological filtering is based on mathematical morphology (set theory description of the Images). It deals with tools for extracting image components that are useful in the representation and description of the shape. Dilation adds pixels to the boundaries ofobjects (*i.e.*, changes them from off to on).

(*d*) Otsu's Algorithm and R-peak detection: Otsu's algorithm has been performed for image adaptive binarization. Adaptive threshold technique for image binarization yields better results as compared to global thresholds [3]. Otsu's method is used to automatically perform histogram shape-based image thresholding or the reduction of a graylevel image to a binary image. The algorithm assumes that the image to be thresholded contains two classes of pixels or bi-modal histogram (*e.g.* foreground and background) then calculates the optimum threshold separating those two classes so that their combined spread (intra-class variance) is minimal.

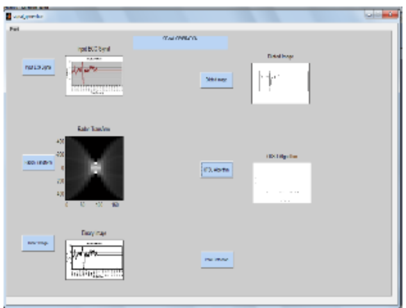

Fig. 2. Output Form digital time series Signal generation.

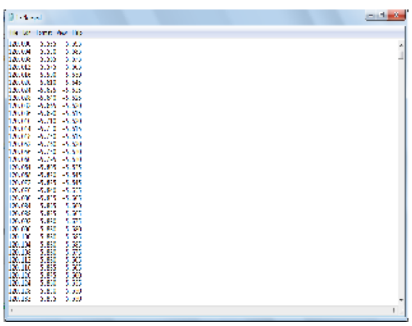

Fig. 3. Peak Detection values from digital time series Signal generation.

B. The Classification of ECG using Neural Network

The output generated signal from the first step i.e. Signal generation serves as Real data input to the second step i.e. the Classification of ECG using Neural Network for the normal or abnormal diagnoses of the ECG. The signal is imported and pre-processing or Filtration of the image is done which thereby undergoes parameter calculation such as Standard Deviation, Correlation, and Wavelet Coefficient etc for the performance of the image. Finally the Neural Network is trained and tested using these values and normality and Abnormality of the ECG is obtained.

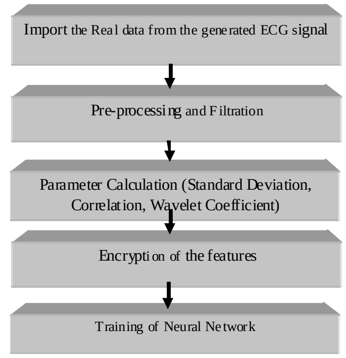

Fig. 4. Algorithm for Classification of Neural Network.

(*a*) *Import Signal and Pre-processing:* The signal generated from the first part serves as a real data input to the second part. The real data of the generated signal is imported and loaded. The Loaded image is pre-processed and filtered. The filter function is shaped so as to attenuate some frequencies and enhance others.

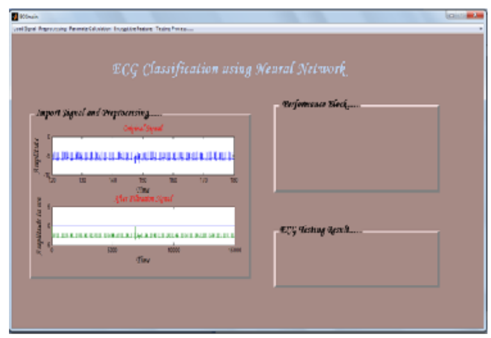

Fig. 5. Import Signal and Pre-processing.

(*b*) *Parameter Calculation:* The next step is the calculation of the performance parameters like Standard Deviation, Correlation, Wavelet Coefficient of the image.

Standard Deviation shows how much variation or "dispersion" there is from the average (mean, or expected value).

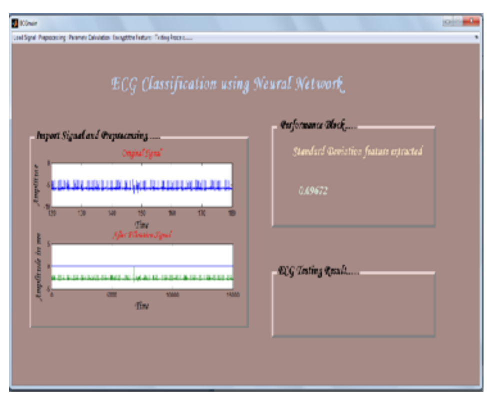

Fig. 6. Standard Deviation feature extraction.

Correlation dimension is a measure of the dimensionality of the space occupied by a set of random points, often referred to as a type of fractal dimension.

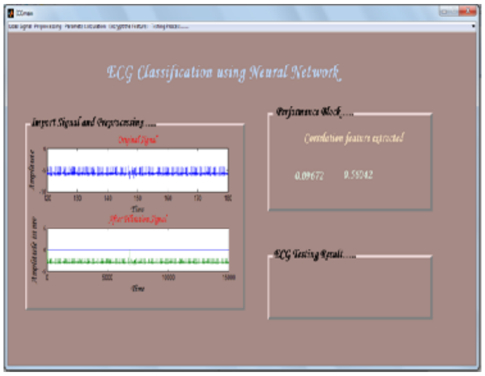

Fig. 7. Correlation feature extraction.

Wavelet Transform (WT) is a technique for analyzing signals. In this paper Haar Wavelet is used. Haar wavelet is a sequence of rescaled "square-shaped" functions which together form a wavelet family or basis. It was developed as an alternative to the short time Fourier Transform (STFT) to overcome problems related to its frequency and time resolution properties. More specifically, unlike the STFT that provides uniform time resolution for all frequencies the DWT provides high time resolution and low frequency resolution for high frequencies and high frequency resolution and low time resolution for low frequencies.

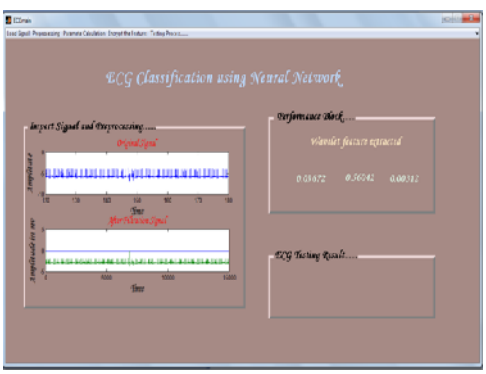

Fig. 8. Wavelet feature extraction.

(*c*) Encrypt the features and Training process: Encryption can protect the confidentiality of features but other techniques are still needed to protect the integrity and authenticity of features. The training of Neural Network is done by Levenberg Marquardt training algorithm.

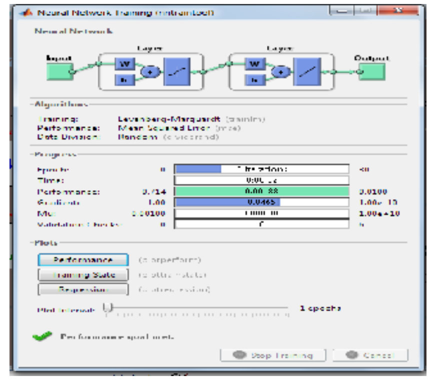

Fig. 9. Neural Network Training process result.

Performance Plots of Trained Neural Network

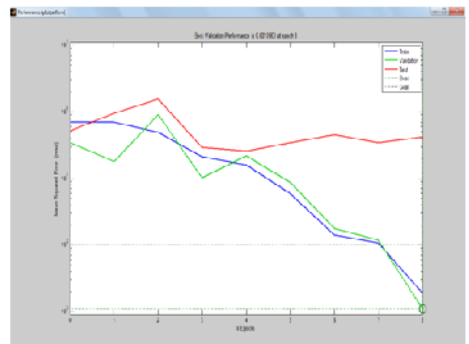

Fig. 10. Mean square error (MSE) Plot.

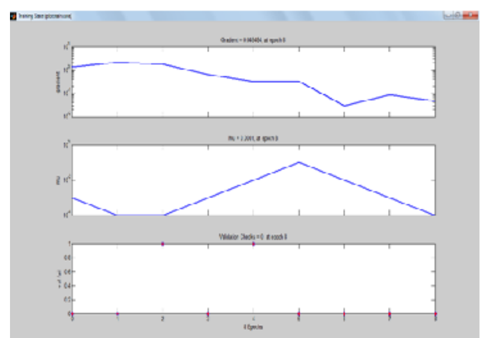

Fig. 11. Gradient and Validation Check Plot.

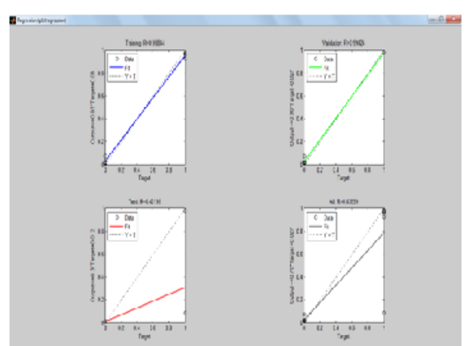

Fig. 12. Regression Plot.

IV. TESTING AND SIMULATION RESULT AND DISCUSSION

For the specific ECG input, the testing results after training Neural Network is Normal Signal. From this test results it is analysed that the concerned person's ECG is detected as normal and the person is not suffering from any Cardiac problem. In the same way analysis can be carried out for number of other ECG inputs and the respective diagnoses can be made on the basis of the testing result as normal or abnormal and the patient can be helpful in the early treatment in case of abnormality.

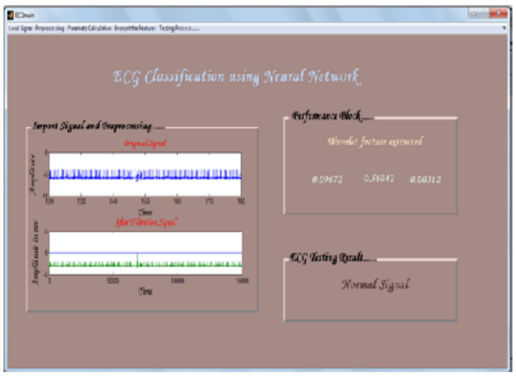

Fig. 13. ECG testing results.

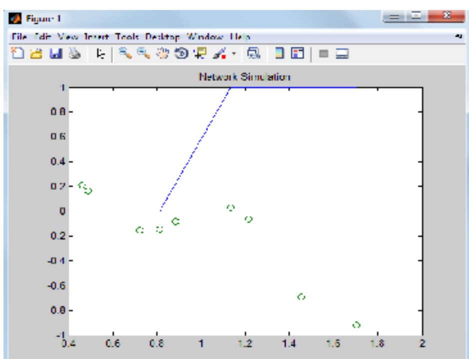

Fig. 14. Network Simulation.

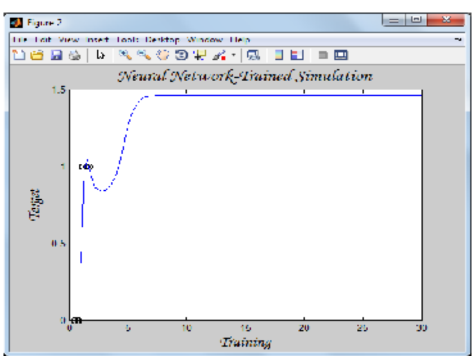

Fig. 15. Neural Network Trained Simulation.

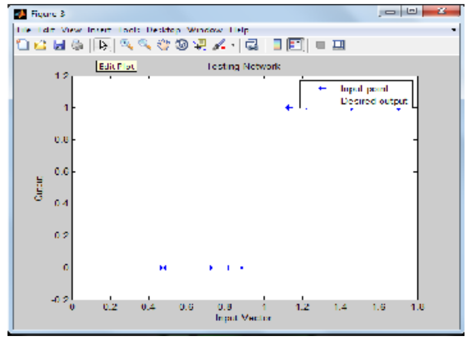

Fig. 16. Testing Network.

VI. CONCLUSION AND FUTURE SCOPE

The soft computing technique not only helps in accurate detection but also the diagnoses irrespective of the physician which helps in early stage treatment of the patient in case of abnormality thereby saving lives of many. This method of the normality and abnormality detection is an accurate and converting ECG records into a computer based digitised signal reduces the physical storage space and the retrieval of the requisite information can be made quicker and accurate. This application can further be enchanced in diagnoses of a particular cardiac disease which could even help in much better way for the detection of cardiac problem and treatment for the same.

REFERENCES

[1] Shahanaz Ayub1, J.P. Saini2, "ECG classification and abnormality detection using cascade forward neural Network," *International Journal of Engineering, Science and Technology*, Vol. **3**, No. 3, (2011), pp. 41-46

[2] Soumya Ranjan Mishra and K. Goutham, "Realtime classification of ecg waveforms for diagnosis of diseases", Thesis National Institute of Technology, Rourkela, (2009-2010).

[3] Prashanth Swamy, Srinivasan Jayaraman, M.Girish Chandra, "An Improved Method for Digital Time Series Signal Generation from Scanned ECG Records" TCS Innovation Labs, Tata Consultancy Services, Bangalore, India {prashanth.swamy, srinivasa. j., m.gchandra}@tcs.com

[4] Shahnaz Ayub and J.P. Saini, "Abnormality Detection in ECG Using Artificial Neural Networks," Electronic Journal of Biomedicine, Spain, ISSN 1697-090X, *English/Spanish/ Portuguese*, vol. **3**, pp. 47-52, Dec. (2010).

[5] Shahanaz Ayub and J.P. Saini. "Extraction of Ventricular Premature Beats from ECG using Soft Computing Technique", *International Journal of Electronics Engineering*, **2**(1): (2010), pp. 155-158